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In re Application of:

Applicants: Masahiro KONISHI et al. ) Group Art Unit:2612  
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Hernandez

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For: IMAGE SIGNAL PROCESSOR FOR PERFORMING IMAGE  
PROCESSING APPROPRIATE FOR AN OUTPUT DEVICE  
AND A METHOD THEREFOR

Hon. Commissioner of Patents & Trademarks  
Washington D.C. 20231

Dear Sir:

DECLARATION OF TRANSLATOR

I, Kouichi Kushida, a Japanese Patent Attorney registered No. 11741, having my business office at TG115 Bldg., 15-7, Toranomon 1-chome, Minato-ku, Tokyo 105-0001 Japan, solemnly and sincerely declare that I made an English translation attached hereto of Japanese patent application No. 228950/1999, which was originally filed with the Japanese Patent Office on August 13, 1999, in the name of Fuji Photo Film Co., Ltd.

I further declare that the attached translation is, to the best of my knowledge and belief, a true and correct translation of Japanese patent application No. 228950/1999, and that all the preceding statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of the Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the above-identified patent application or any patent issuing thereon.

Subscribed on this 8<sup>th</sup> day of March, 2005

Translator: Kouichi Kushida  
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PATENT OFFICE  
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This is to certify that the annexed is a true copy of the following application as filed with this Office.

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(Seal)

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[Document Name] SPECIFICATION

[Title of the Invention] IMAGE SIGNAL PROCESSOR AND ITS PROCESSING METHOD

[Claim(s)]

[Claim 1] An image signal processor for performing image processing on a first image signal, obtained by imaging and photo-electrically converting incident light from a subject field with imaging means, to produce a second image signal, comprising:

first storing means for storing therein said first image signal;

a plurality of processing means for each performing image processing, different from each other, on the stored first image signal to produce the second image signal different from each other; and

second storing means for storing therein a plurality of second image signals produced by the plurality of processing means,

wherein said plurality of processing means perform image processing such that at least one of the types and parameter data of the image processing are different between the processing means.

[Claim 2] The image signal processor according to claim 1, wherein the types of image processing performed by said plurality of processing means include at least one selected from a group consisting of a change of brightness, a change of gradation change characteristics, a correction of a color temperature, a change of saturation, a change of a contour, a change of a compression ratio and a change of a black level of the first image signal stored in said first storing means,

said parameter data include at least the data of the subjects for processing among said brightness, gradation change characteristics, color temperature, saturation, contour,

compression ratio and black level, and

said plurality of processing means produce, according to the parameter data, said plurality of second image signal by performing the change of brightness, the change of gradation change characteristics, the correction of the color temperature, the change of saturation, the change of the contour, the change of the compression ratio and the change of the black level of the first image signal stored in said first storing means.

[Claim 3] The image signal processor according to claims 1 or 2 wherein each of said plurality of processing means corresponds to one of a plurality of display means which are provided for visualizing the stored second image signals output from said second storing means,

each of said plurality of processing means produce, according to said parameter data, the second image signals to be displayed on one of the display means which corresponds to said processing means.

[Claim 4] The image signal processor according to claim 3 wherein said plurality of display means include CRT display means and image printing means.

[Claim 5] The image signal processor according to any one of claims 1 to 4, further comprising divider means for dividing the image signal stored in said first storing means into a highlight area and a shadow area,

each of said plurality of processing means performing the image processing in which at least one of the types and the parameter data of the image processing differs between the highlight area and the shadow area.

[Claim 6] The image signal processor according to any one of claims 1 to 5 wherein said second storing means is detachably connected to said image signal processor.

[Claim 7] An image signal processor for performing image processing on a first image signal, obtained by imaging and photo-electrically converting incident light from a subject

field with imaging means, to produce a second image signal, comprising:

first storing means for storing therein said first image signal;

a plurality of processing means for each performing image processing, different from each other, on the stored first image signal to produce the second image signal different from each other;

second storing means for storing therein a plurality of second image signals produced by the plurality of processing means; and

image composer circuit for composing the plurality of second image signals to produce third image signal,

wherein said plurality of processing means perform image processing such that at least one of the types and parameter data of the image processing are different between the processing means.

[Claim 8] The image signal processor according to claim 7, further comprising divider means for dividing the image signal stored in said first storing means into a highlight area and a shadow area,

wherein said plurality of processing means are provided correspondingly to the highlight area and the shadow area, each of said plurality of processing means performing the image processing for one of the highlight area and the shadow area to produce said second image signals.

[Claim 9] A method of processing a first image signal, obtained by imaging and photo-electrically converting incident light from a subject field with imaging means, to produce a second image signal, comprising the steps of:

storing said first image signal in a memory;

performing a same type of image processing on the stored first image signal according to parameter data of image processing different from each other to produce a plurality

of second image signals; and

storing the plurality of produced second image signals in a memory.

[Detailed Description of the Invention]

[0001]

[Art Field Pertinent to the Invention]

The present invention relates to an image signal processor for processing image signals obtained by imaging incident light from a subject field with imaging means, and a method of processing the image signals.

[0002]

[Prior Art]

Some conventional cameras using silver-halide photosensitive films or digital still cameras have a function, so-called auto-bracketing, that continuously photographs a sequence of frames while gradually shifting the exposure to the underexposure side or overexposure side around the standard exposure of the camera.

[0003]

A camera using silver-halide photosensitive films which performs auto-bracketing is disclosed in Japanese Patent Laid-Open Publication No. 249534/1993. This camera can decide the parameters, such as the number of frames to be photographed and the exposure correction amount, without receiving instructions from the user.

[0004]

[Problems to Be Solved by the Invention]

A camera that performs auto-bracketing according to the prior art photographs a plurality of frames, meaning that the photographed images differ in time. For example, when seven

frames are photographed at 0.2-second intervals each at one of seven exposure levels, there is a 1.2-second difference in time between the first frame and the last frame. Therefore, the movement of the object, the change in the photographing conditions, the unintentional movement of the hands of the user in shooting the object, and the like during the shooting period of time make it difficult to appropriately photograph a desired image.

[0005]

The present invention seeks to solve the problems associated with the prior art described above. It is therefore an object of the present invention to provide an image signal processor, and also a method of processing an image signal, that allows the user to obtain a desired image during auto-bracketing. Furthermore, the present invention enables generation of a plurality of images which are different from each other in color balance, sharpness, gradation characteristics and the like, which would not be achieved only by changing the exposure amount.

[0006]

[Means to Solve the Problems]

To solve the above problems, an image signal processor for performing image processing on a first image signal, obtained by imaging and photo-electrically converting incident light from a subject field with imaging means, to produce a second image signal, comprises: first storing means for storing therein the first image signal; a plurality of processing means for each performing image processing, different from each other, on the stored first image signal to produce the second image signal different from each other; and second storing means for storing therein a plurality of second image signals produced by the plurality of processing means, wherein the plurality



of processing means perform image processing such that at least one of the types and parameter data of the image processing are different between the plurality of processing means.

[0007]

Advantageously, the types of image processing performed by the plurality of processing means may include at least one selected from a group consisting of a change of brightness, a change of gradation change characteristics, a correction of a color temperature, a change of saturation, a change of a contour, a change of a compression ratio and a change of a black level of the first image signal stored in the first storing means; the parameter data of image processing include at least the data of the subjects for processing among the brightness, gradation change characteristics, color temperature, saturation, contour, compression ratio and black level; and the plurality of processing means produce, according to the parameter data, the plurality of second image signal by performing the change of brightness, the change of gradation change characteristics, the correction of the color temperature, the change of saturation, the change of the contour, the change of the compression ratio and the change of the black level of the first image signal stored in the first storing means.

[0008]

In addition, in accordance with an aspect of the invention, each of the plurality of processing means may correspond to one of a plurality of display means which are provided for visualizing the second image signals by inputting the second image signals stored in the second storing means, each of the plurality of processing means producing, according to the parameter data, the second image signals to be displayed on one of the display means which corresponds to the processing means.

[0009]

At this time, CRT display means and image printing means may be selected as the plurality of display means.

[0010]

In a further aspect of the invention, the image signal processor may further comprise divider means for dividing the image signal stored in the first storing means into a highlight area and a shadow area, each of the plurality of processing means performing the image processing in which at least one of the types and the parameter data of the image processing differs between the highlight area and the shadow area.

[0011]

In addition, it is preferable that the second storing means is detachably connected to the image signal processor.

[0012]

Further in accordance with the present invention, an image signal processor comprises: first storing means for storing therein a first image signal; a plurality of processing means for each performing image processing, different from each other, on the stored first image signal to produce a second image signal different from each other; second storing means for storing therein a plurality of second image signals produced by the plurality of processing means; and image composer means for composing the plurality of second image signals to produce a third image signal, wherein the plurality of processing means perform image processing such that at least one of the types and parameter data of the image processing are different between the plurality of processing means.

[0013]

Advantageously, the image signal processor may further comprise divider means for dividing the image signal stored in the first storing means into a highlight area and a shadow area, wherein a plurality of processing means are provided to correspond to the highlight area and the shadow area, and each of the plurality of processing means produces a second image signal by performing the image processing on either of the highlight area and the shadow area.

[0014]

Still further in accordance with the present invention, a method of processing a first image signal, obtained by imaging and photo-electrically converting incident light from a subject field with imaging means, to produce a second image signal comprises the steps of: storing the first image signal in a memory; performing the same type of image processing on the stored first image signal according to parameter data of image processing different from each other to produce a plurality of second image signals; and storing the plurality of second image signals in a memory.

[0015]

#### [Embodiments of the Invention]

Referring to the accompanying drawings, preferred embodiments of an image signal processor and its processing method according to the present invention will be described in detail.

[0016]

An image signal processor according to the present invention is adapted to store a frame of image data (a first image signal) formed by an imaging device into a buffer memory, set up control values of image signal processing (image parameter information) on various situations for the frame of image data

thus stored, and process the image signal for each of those situations to generate and store a plurality of frames of image data (second image signals) in a storage. This processor therefore allows various images, which meet various purposes, to be formed from one frame of photographed image data.

[0017]

The image signal processor according to the present invention may be applied to a digital camera. In this specification, a digital camera refers to a photographing device, such as an electronic still camera and a digital video camera, which photographs still images or movie images for recording them in the form of digital signals.

[0018]

The specific embodiments of the present invention described are a digital camera which has a single-plate color filter provided immediately in front of the photosensitive array and, especially, an electronic still camera. Referring to FIGS. 1-12, the configuration and the operation of the electronic still camera according to the present invention will be described.

[0019]

An electronic still camera in a first preferred embodiment of the present invention can achieve a purpose similar to auto-bracketing according to the prior art by simply photographing an object only once. The embodiment of the electronic still camera can also perform image processing to generate a plurality of different frames of image data that could not be done by changing the exposure amount only.

[0020]

In addition, the electronic still camera in the first

embodiment is adapted to generate image signals in compliance with various types of display means (more specifically, a CRT or a printer), by which photographed image signals are to be visualized in the form of pictures. In the description below, processing for generating image signals compliance with a type of display means is called "usage-specific image processing".

[0021]

In the first embodiment, usage-specific image processing is performed on each of a plurality of frames of image data generated by image processing that is performed by changing image processing parameters. This processing, which includes processing corresponding to the auto-bracketing function according to the prior art, is called "gain adjustment". It should be noted that gain adjustment and usage-specific image processing are independent of each other. One of them may be executed independently.

[0022]

As shown in FIG. 1, an electronic still camera 10 in the first embodiment comprises a camera proper 11 and a detachable memory card attachment 20 connected together via a connector 30. The camera proper 11 comprises an optical system 11a, a color filter 11b, a CCD (Charge-Coupled Device) image sensor 11c, a preprocessor 11d, an analog-to-digital (A/D) converter 11e, a signal processor 12, a data compressor 11f, an input/output interface 11g, a data input unit 11h, and a system controller 13. The memory card attachment 20 comprises an input/output interface 21 and a memory card 22.

[0023]

The optical system 11a comprises a photographing lens 110a, an iris and components associated therewith, not shown in the figure. The color filter 11b is a single-plate as

described above. Generally, a Bayer pattern, one of primary color patterns, is applied on the electronic still camera 10 for arranging a color filter array. In the description below, three primary colors are represented by R (red), G (green) and B (blue). The present invention may be applied regardless of the color filter arrangement type. This color filter array 11b is provided immediately before the photosensitive array of the CCD image sensor 11c.

[0024]

On the CCD image sensor 11c, the photosensitive cells, or photodiodes, of the CCD image sensor 11c corresponding in position to the filter segments of the color filter 11b are provided to form an array of pixels. When incident light from the subject field falls on those cells, the cells photo-electrically convert the incident light into electric charges. The CCD image sensor 11c outputs signal, corresponding to the pixels, to the preprocessor 11d.

[0025]

The preprocessor 11d is adapted to amplify the supplied signal to a desired level and outputs the amplified signal to the A/D converter 11e. The A/D converter 11e is adapted to convert the analog signal, output from the preprocessor 11d, to the digital signal.

[0026]

The signal processor 12 is adapted for performing color correction on the digital signal thus received, storing the color-corrected digital signal temporarily into the buffer memory, and performing the image processing (gain adjusting and usage-specific image processing) on the stored digital signal to generate a plurality of frames of image data. The signal processor 12 may comprise a special-purpose IC

(Integrated Circuit), a general-purpose CPU (microprocessor), or a DSP (Digital Signal Processor). It should be noted that the IC, CPU, or DSP may comprise not only the signal processor 12 but also the function of the data compressor 11f which will be described later.

[0027]

The signal processor 12, which is one entity, has a plurality of image processing features to perform various types of processing on the stored first signal to generate second image signals which are different from each other. The signal processor 12 performs a plurality of types of image processing where at least one of the image processing types and parameter information for processing are different from others. A plurality of signal processors, each corresponding to one of the plurality of image processing features, may be provided.

[0028]

As shown in FIG. 2, the signal processor 12 comprises a color interpolation circuit (RGB interpolation circuit) 12a, a buffer memory 12b, a gain adjusting circuit 12c, and a usage-specific processor 12d. The color interpolation circuit 12a, buffer memory 12b, gain adjusting circuit 12c, and usage-specific processor 12d perform processing in response to the control signal from the system controller 13. The control signal contains the timing signal, as well as instructions and data required for processing.

[0029]

The color interpolation circuit 12a is adapted to generate color data at each pixel position, which are not obtainable directly from the CCD image sensor 11c, by interpolating the color data of the surrounding, actual cells. Thus, at each time of photographing, the color interpolation

circuit 12a outputs the R data, G data, and B data at the respective pixel positions to store them into the buffer memory 12b.

[0030]

The buffer memory 12b is adapted to store therein image data supplied from the color interpolation circuit 12a. The memory is large enough, for example, to contain one frame of image data. Image data is input to, and output from, the buffer memory 12b in response to an instruction from the system controller 13. Image data is stored in the buffer memory 12b each time an image of the object is photographed. In response to each instruction from the system controller 13, one frame of image data is output repeatedly from the buffer memory 12b to the gain adjusting circuit 12c.

[0031]

The gain adjusting circuit 12c is adapted to perform gain adjustment on the image data read out from the buffer memory 12b. More specifically, in response to the instruction received from the system controller 13 and indicating how many times gain adjustment is to be executed and the exposure correction amount (parameter information), the gain adjusting circuit 12c multiplies image data from the buffer memory 12b by a predetermined value.

[0032]

For example, when five frames of image data are to be generated during gain adjusting and when the exposure correction amount is to be incremented in steps of 0.5EV (Exposure Value), the system controller 13 issues the instruction described below. The system controller 13 sequentially generates the pixel addresses included in one frame of image data and sends them to the buffer memory 12b. The system controller 13 repeats this processing five times. At the same time, the system



controller 13 sequentially sends exposure correction values, e.g. -1.0, -0.5, 0.0, +0.5, and +1.0, to the gain adjusting circuit 12c to correct the exposure value (EV) each time it sends one frame of image data to the memory buffer. For example, the value -1.0 means that -1.0EV of exposure correction will be executed. In response to this instruction, the gain adjusting circuit 12c performs processing associated with this exposure correction. More specifically, it multiplies the image data from the buffer memory 12b by a value  $1/2$ . The values of -1.0, -0.5, 0.0, +0.5, and +1.0 mean that the gain adjusting circuit 12c will multiply the image data by values  $1/2$ ,  $1/2^{1/2}$ , 1.0,  $2^{1/2}$ , and 2, respectively. It should be noted that those numeric values are examples only but that exposure correction values are not limited to those specific values.

[0033]

The usage-specific processor 12d is adapted to receive image data from the gain adjusting circuit 12c and perform image processing according to the information (parameter information) concerning display means specified by the system controller 13. Image data processing may be appropriate for two types, for example, one for CRT (Cathode Ray Tube) display and the other for printer output (hardcopy) of data, each having its own image quality. In the description below, those two types of processing are called CRT processing and hardcopy processing, respectively. The two types of processing will be described later in detail. The usage-specific processor 12d is also adapted to convert RGB data into luminance data Y and color difference or chrominance data B-Y and R-Y. Although only one processing setting is shown for each of CRT processing and hardcopy processing in the description of the embodiment, the present invention is not limited to the one setting. Two or more settings may be specified depending upon the type of the CRT or the printer. The present invention may also be applied

to display systems other than the CRT, such as a liquid crystal display, an EL (Electro-Luminescence) display, and a plasma display.

[0034]

The signal processor 12 outputs the luminance data Y and the color difference data B-Y and R-Y to the data compressor 11f shown in FIG. 1. The data compressor 11f is adapted to compress the luminance data Y and the color difference data B-Y and R-Y by reducing the number of bits of the data. For compression method, Huffman coding or differential PCM is used. The data compressor 11f uses these compression methods to reduce the data amount and then outputs the reduced data to the input/output interface 11g.

[0035]

The data compressor 11f can compress image data using the compression ratio in accordance with the display means specified by the system controller 13. The compressor uses a higher compression ratio for image data to which the image quality for CRT display was assigned by the usage-specific processor 12d, and a lower compression ratio for image data to which the image quality for printer output was assigned. The processing of the data compressor 11f will be described later in detail.

[0036]

The CCD image sensor 11c, preprocessor 11d, A/D converter 11e, signal processor 12, and data compressor 11f are timed with each other in response to the timing signal output from the system controller 13. The system controller 13 contains a system controller for controlling the constituent elements included in the whole electronic still camera 10, a timing signal generator for generating the timing signal, and

an address controller, not shown in the figure. The system controller also controls the timing signal generator and the address controller to control the whole electronic still camera 10. The timing signal generator, under the control of the system controller, generates the signals which are used for driving the whole electronic still camera 10 and adjusting the operational timing, and supplies those signals to the components as shown in FIG. 1.

[0037]

The address controller outputs address data to the buffer memory 12b to sequentially input image data to, and output image data from, the buffer memory 12b. In addition, to store processed image data into the memory card 22, the system controller 13 outputs required data and addresses to the memory card 22 via the input/output interface 11g and the connector 30 of the camera proper and via the input/output interface 21 of the memory card attachment. The required data includes a filename necessary for image data input/output, a photographing date, a photographing condition (exposure value), an image processing condition (gain adjusting condition, display means information) and the like.

[0038]

The data input unit 11h includes components for user operation such as a mode selector button, a shutter release button, and a liquid crystal monitor on which the mode of the electronic still camera 10 is displayed, not shown in figure. When the user operates the mode selector button or the shutter release button, the data input unit 11h outputs operational result data to the system controller 13.

[0039]

User instructions entered by the mode selector button

include whether to adjust the gain, whether to allow, if the gain is to be adjusted, the electronic still camera 10 to automatically decide the number of frames to be produced and the exposure correction amount, the number of frames to be produced and the exposure correction amount if manually decided by the user, and whether to perform usage-specific image processing.

[0040]

In response to an instruction indicating that, during gain adjusting, the electronic still camera 10 will automatically decide the number of frames and the exposure correction amount, the system controller 13 may decide the proper exposure value, the number of frames, and exposure correction amount according to the method disclosed in Japanese Patent Laid-Open Publication No. 249534/1993.

[0041]

The signal processor 12, adapted for processing digital signals, may be implemented in the form of dedicated digital signal processing IC. Because the primary operational function of the processor is multiplication and addition, a general-purpose DSP (Digital Signal Processor) may also be applicable.

[0042]

Next, referring to FIGS. 3 and 4 showing the detailed configurations of the gain adjusting circuit 12c and the usage-specific processor 12d, respectively, the signal processor 12 with the components described above will be described more in detail.

[0043]

As shown in FIG. 3, the gain adjusting circuit 12c

comprises a multiplier 121 and a gain setter 122. The multiplier 121 receives image data from the buffer memory 12b. It is assumed that image data is sent from the buffer memory 12b to the gain adjusting circuit 12c in the general display scanning fashion of a CRT monitor. That is, after one line of pixel data is output horizontally from the buffer memory 12b, image data on the next line is output. One pixel of data, containing 24 bits in length (8 bits for each of R, G, and B), is sent over eight signal lines, i.e. eight bits in parallel.

[0044]

The gain setter 122 receives an exposure correction amount instruction from the system control 13. For example, when the instruction indicating the value of "-1.0" is received from the system control 13, the gain setter 122 then sets the gain of the multiplier 121 to  $1/2$ . Then, the multiplier 121 multiplies the received image data by  $1/2$  and outputs the result to the gain adjusting circuit 12c. When no gain adjusting is performed, the system controller 13 sends the instruction indicating the value of "0.0" to the gain setter 122. This instruction means that image data from the buffer memory 12b is sent to the usage-specific processor 12d without making any change in the gain adjusting circuit 12c.

[0045]

FIG. 4 shows the usage-specific processor 12d which receives image data from the gain adjusting circuit 12c. The usage-specific processor 12d comprises a selector 123, a gain control 124, a gradation control 125 comprising LUTs (Look Up Tables), a luminance-chrominance matrix 126, a contour enhancement circuit 127, a saturation emphasizing circuit 128, and a parameter setter 129, interconnected as shown in the figure.

[0046]

The selector 123 distributes RGB data, received sequentially from the gain adjusting circuit 12c, into R data, G data, and B data. This distribution allows processing for each color to be executed independently if necessary.

[0047]

The gain control 124 amplifies each color data distributed by the selector 123. More specifically, the gain control 124 multiplies color data by a numeric value predetermined for the display means (CRT or hardcopy).

[0048]

The gradation control 125 performs gradation conversion, that is, processing such as gamma correction. More specifically, the gradation control 125 includes a gradation correction curve defining the correspondence of the value of color data to be output with respect to the value of received color data, and converts the received color data according to the correction curve. FIG. 5 shows some examples of gradation correction curves. FIGS. 5(a) and 5(b) show the gradation correction curves to be used for CRT processing and hardcopy processing, respectively. In FIGS. 5(a) and 5(b), the horizontal axis indicates the value of entered color data, and the vertical axis indicates the output value of color data corresponding to the received color data.

[0049]

These curves are employed for the reasons described below. The correction curve in FIG. 5(a) is used for a CRT because the photoelectric conversion characteristics of the CRT screen is usually  $2.2^{\text{th}}$  power of the input, so that conversion using  $0.45^{\text{th}}$  power of the input ( $0.45$  is the reciprocal of  $2.2$ ) is performed. Using this correction curve makes the contrast

relatively lower than the contrast before gradation correction. Therefore, this type of correction is called "contrast decreasing".

[0050]

The gradation correction curve in FIG. 5(b) is used for a hardcopy because the S-shaped characteristics are desirable when restoring the contrast of image data on a hardcopy. That is, since it is usually important to retain definite contrast, or intensity difference, on a hardcopy, a sharper contrast is desired. The intermediate portion of the S-shaped curve has a slope corresponding to  $\gamma=1$ . This portion corresponds to the flesh color, and  $\gamma=1$  is desirable for the flesh color. Using this correction curve makes the contrast relatively higher than the contrast before corrected in gradation. Therefore, this type of gradation correction is called "contrast increasing".

[0051]

It is also possible for the gain control and the gradation control to use a gain and a gamma correction curve which are different in dependent upon colors of image data.

[0052]

The luminance-chrominance matrix 126 is adapted to perform matrix operation to convert RGB data to the luminance signal (Y) and color difference signal (Cr, Cb). The matrix operation is performed using the expressions read below.

[0053]

[Expression 1]

$$\begin{aligned} Y1 &= K11 \times R1 + K12 \times G1 + K13 \times B1, \\ Cr1 &= K21 \times R1 + K22 \times G1 + K23 \times B1, \\ Cb1 &= K31 \times R1 + K32 \times G1 + K33 \times B1, \end{aligned}$$

where, R1, G1, and B1 are color data that is input to the luminance-chrominance matrix 126. They represent the red, green, and blue components, respectively. K11, K12, K13, K21, K22, K23, K31, K32, and K33 are conversion coefficients. Y1 is the luminance signal that is output by the luminance-chrominance matrix 126. Cr1 and Cb1 are color difference signals output by the luminance-chrominance matrix 126. The luminance signal Y1 is sent to the edge enhancing circuit 127, and the color difference signals Cr1 and Cb1 are sent to the saturation emphasizing circuit 128.

[0054]

The edge enhancing circuit 127 emphasizes the contour of image data (aperture) to increase the contrast of the whole image. A known method may be used for emphasizing the contour of a picture. For example, to emphasize a horizontal contour line, the method described below is performed. The original signal Y0 is delayed by one horizontal scan period of time 1H into a 1H-delayed signal YH, and by two horizontal scan periods of time 2H into a 2H-delayed signal Y2H. In this case,  $YH + K \times [YH - (Y0 + Y2H) / 2]$  is the luminance signal in which the horizontal contour line is emphasized, where K is a constant defining the degree of emphasizing the contour line. The larger the value K, the more emphasized the contour. This processing may be performed by a low-pass filter (LPF).

[0055]

A similar known method may be used for emphasizing a vertical contour line. The original signal Y0 is delayed by the predetermined delay time  $1\tau$  into a delayed signal  $Y\tau$ , and by two times of the delay time, i.e.  $2\tau$  into a delayed signal  $Y2\tau$ . In this case,  $Y\tau + K \times [Y\tau - (Y0 + Y2\tau) / 2]$  is the luminance signal in which the vertical contour line is emphasized.



[0056]

The saturation emphasizing circuit 128 is adapted to modify the color difference signal to convert saturation. More specifically, the circuit 128 multiplies a numeric value predetermined according to the display means by the color difference signal. More specifically, the saturation is represented by  $(Cr^2 + Cb^2)^{1/2}$ . To emphasize the saturation, the circuit 128 multiplies the color difference signals Cr and Cb, by a predetermined numeric value. The same predetermined value, or different predetermined values, may be used for the color difference signal Cr and the color difference signal Cb. The predetermined numeric value should be decided considering the hue.

[0057]

Table 1 shows in the column of usage-specific image processing how the gain control 124, gradation control (LUTs) 125, luminance-chrominance matrix 126, edge enhancing circuit 127, and saturation emphasizing circuit 128 convert image data for the specific display means during the CRT processing and the hardcopy processing described above.

[0058]

[Table 1]

	Usage-specific image processing	
	CRT processing	Hardcopy processing
Gain	Large	Small
LUT	A	B
Matrix coefficient	Change	Change
Contour enhancing	Strong	Weak
Saturation emphasis	Strong	Weak
Compression ratio	High	Low

The row Gain in Table 1 represents the gain control of the gain control 124, and the row LUT represents the gradation

correction of the gradation control 125. Note that the letter "A" in this row indicates the gradation correction curve plotted in FIG. 5(a) and that "B" indicates the correction curve shown in FIG. 5(b). The row Matrix coefficient represents the conversion of the luminance-chrominance matrix 126, and the rows Contour enhancing and the Saturation emphasis represent the conversion of the edge enhancing circuit 127 and the saturation emphasizing circuit 128. The row Compression represents the conversion of the data compressor 11f shown in FIG. 1.

[0059]

The reason for the settings shown in Table 1 will be described. In general, when comparing the color range which a CRT can represent with the color range which a hardcopy (especially a printer) can represent, the color range which the CRT can represent is wider. On a CRT, a brighter image looks clearer. On a hardcopy, a darker image looks clearer.

[0060]

For that reason, on a CRT the gain and the saturation emphasis are increased whereas on a hard copy the gain and the saturation emphasis are decreased. Also, the contour enhancement is increased on a CRT because a contour-enhanced, sharp image is desirable. On the other hand, the contour enhancement is decreased on a hardcopy because a soft image is desirable. The reason for the LUT setting was described with reference to the gradation control 125. The compression ratio will be described later.

[0061]

In response to the signal indicating the type of display system from the system controller 13, the parameter setter 129 shown in FIG. 4 sets the value in the components of the

usage-specific processor 12d according to the setting shown in Table 1.

[0062]

More specifically, for the gain control 124, the parameter setter 129 has two types of coefficients (corresponding to the gains of the amplifier) for two types of display systems. In response to the instruction from the system control 13, the parameter setter 129 outputs one of two types of coefficients to the gain control 124. The gain control 124 multiplies color data by the coefficients.

[0063]

The parameter setter 129 performs the same setting for the saturation emphasizing circuit 128.

[0064]

To the gradation control 125, the parameter setter 129 outputs the signal which specifies a gradation correction curve. The setter 129 also outputs the above-described coefficients, which specify to which extent the contour is to be emphasized, to the edge enhancing circuit 127.

[0065]

The image data, processed by the usage-specific processor 12d of the signal processor 12 as described above, is sent to the data compressor 11f shown in FIG. 1. In response to an instruction from the system controller 13 indicating whether to increase or decrease the compression ratio, the data compressor 11f compresses the received image data according to the instruction. The image data may be compressed, for example, based on the JPEG (Joint Photographic coding Experts Group) standard. In the JPEG standard, image data is compressed by sequentially performing DCT (Discrete Cosine Transform)

processing, quantization, and coding (run length coding and Huffman coding). To change the compression ratio, the quantization table used for quantization should be changed. Specifically, two tables are prepared, one for higher compression and the other for lower compression. The image data is quantized using either of the two quantization tables in dependent upon the specified compression ratio.

[0066]

The reason for setting the compression ratio, as shown in Table 1 in accordance with the display means, is that a higher compression ratio is selected for a wider range image data to be used for CRT processing whereas a lower compression ratio for a narrower range image data to be used for hard copy processing. This setting allows one frame of image data to be stored in the same memory capacity.

[0067]

The compressed image data is sent to the memory card 22 and stored therein. The memory card may be a semiconductor memory (flash memory, and the like), a magnetic disk, or an optical disc.

[0068]

Next, the operation of the electronic still camera 10 with configuration described above will be described.

[0069]

In operation, the user manipulates the data input unit 11h to specify whether to perform gain adjusting and usage-specific image processing. When the user wants to do gain adjusting, he or she must specify the number of image data frames to be created and the exposure correction amount. In response to the user instruction, the system controller 13

decides whether to perform gain adjusting and/or usage-specific image processing. When both gain adjusting and usage-specific image processing are to be performed, the system controller 13 causes the signal processor 12 to do its processing the number of times equal to two times of the number of processing cases during gain adjusting. In the description below, assume that the user has specified that both gain adjusting and usage-specific image processing are to be performed, that the number of processing cases during gain adjusting is three, and that the exposure correction amount is incremented in steps of 1EV. In this case, six frames of image data will be finally obtained.

[0070]

When the user depresses the shutter release button after specifying the processing mode setting, the imaging device 11c captures an image of a subject. The obtained image data is processed by the preprocessor 11d and the A/D converter 11e and then sent to the signal processor 12. The image data, for which color interpolation is performed by the color interpolation circuit 12a of the signal processor 12, is in turn stored in the buffer memory 12b. Each time an output instruction and an address are received from the system controller 13, the image data is sent from the buffer memory 12b to the gain adjusting circuit 12c. In response to the instruction from the system controller 13, the gain adjusting circuit 12c sequentially shifts the coefficients 1/2, 1.0, 2.0, 1/2, 1.0, 2.0, by which the image data is to be multiplied.

[0071]

The image data for which gain-adjusting has been performed is sent to the usage-specific processor 12d. The usage-specific processor 12d performs CRT processing for the first three frames of image data, and hardcopy processing for

the last three frames of image data, according to the settings in Table 1.

[0072]

After usage-specific image processing, the first three frames of image data are compressed at a higher compression ratio, and the last three frames of image data at a lower compression ratio. Then, the compressed data is sent to the memory card, one frame of data at a time.

[0073]

Unlike a camera that performs auto-bracketing according to the prior art, the electronic still camera according to the present invention photographs an image only once. Therefore, a problem that the photographing timing differs with photographed images does not arise. As a result, the user may obtain a desired image without concerning the movement of an object, changing image-shooting conditions, or unintentional movement of the operator's hands during photographing.

[0074]

From the six processing options listed in Table 1, i.e. the gain, LUT, matrix coefficients, contour enhancement, saturation emphasis, and compression ratio, one to five processing methods may be selected and combined.

[0075]

Next, second embodiment of the present invention will be described. In this embodiment, white balance correction and brightness correction are made as gain adjusting in a plurality of ways. While balance correction is made by three adjustments, that is, gain adjustment, matrix coefficient adjustment, and saturation adjustment.

[0076]

Gradation correction is performed for brightness correction. To do so, in this embodiment one frame of image is dealt with as two parts according to the amount of light: a bright part where light falls (highlight area) and a shadowy part where little or no light falls (shadow area). Different parameters are used for the highlight area and the shadow area. This processing will be described later in detail.

[0077]

One or both of white balance correction and brightness correction may be made for one frame of image data. The user may specify how correction will be made.

[0078]

In this embodiment, black level offsetting is also done. The black level refers to the status in which the gradation value is null. Black level offsetting refers to the increase or decrease of the gradation value of the whole image by a predetermined amount. The purpose of black level offsetting is to decrease the gradation value when the whole image looks too whitish due to a halation or to increase the gradation value to brighten the whole area of the image photographed at night.

[0079]

Black level offsetting is done by adding or subtracting a predetermined value to or from the whole image data using an adder.

[0080]

Black level offsetting may also be done in the first embodiment. In the first embodiment, an adder may be added before or after the multiplier of the gain adjusting circuit 12c to offset the black level.

[0081]

The instant embodiment is similar to the first embodiment except for the configuration and the operation of the signal processor, system controller, and data input unit. The remaining components, i.e. the optical system 11a, color filter array 11b, CCD image sensor 11c, preprocessor 11d, A/D converter 11e, data compressor 11f and input/output interface 11g of the camera proper, and the input/output interface 21 and memory card 22 of the memory card attachment 20, perform the same processing as those of the first embodiment.

[0082]

Therefore, the second embodiment will be described below with emphasis on the signal processor, system controller, and data input unit. The same reference numbers denote the components having the function similar to that in the first embodiment. The description of such components is omitted.

[0083]

As shown in FIG. 6, an electronic still camera 10A in the second embodiment comprises a camera proper 11A and the memory card attachment 20 connected together via the connector 30. The camera proper 11A comprises the optical system 11a, the color filter array 11b, the CCD image sensor 11c, the preprocessor 11d, the A/D converter 11e, a signal processor 212, the data compressor 11f, the input/output interface 11g, a data input unit 11hA, and a system controller 13A. The memory card attachment 20 comprises the input/output interface 21 and the memory card 22.

[0084]

The signal processor 212 makes color correction in response to the digital signal from the A/D converter 11e,



temporarily stores the color-corrected digital signal into the buffer memory, and performs image processing (gain adjusting) on the stored digital signal to generate a plurality of frames of image data.

[0085]

As shown in FIG. 7, the signal processor 212 comprises the color interpolation circuit 12a, the buffer memory 12b, an area extractor 212a, an area storage 212b, and a gain adjusting circuit 212c. The color interpolation circuit 12a, buffer memory 12b, area extractor 212a, area storage 212b, and gain adjusting circuit 212c are adapted to perform the processing in response to the control signal from the system controller 13A. The control signal contains the timing signal, as well as instructions and data required for processing that will be described later.

[0086]

The buffer memory 12b stores therein image data supplied from the color interpolation circuit 12a. The memory 12b is large enough, for example, to contain one frame of image data. Image data is input to, and output from, the buffer memory 12b in response to an instruction from the system controller 13A. Image data is stored in the buffer memory 12b each time an image is photographed.

[0087]

When brightness correction is made, one frame of image data is output first from the buffer memory 12b to the area extractor 212a in response to an instruction from the system control 13A. The area extractor 212a extracts the highlight area and the shadow area. This extraction will be described with reference to FIG. 8. FIG. 8(a) shows an image photographed outdoors on a fine day under the daylight against the sun or

against a bright background. This photograph shows the highlight area and the shadow area most clearly.

[0088]

One frame of image shown in FIG. 8(a) comprises shadowy part (shadow area) A and highlight area B which is the fair sky, clouds, or a bright background. This image, where the shadow is dark, gives a sharp impression. By increasing the brightness of shadowy part A and decreasing the brightness of bright part A, the shadow is decreased and the image looks softer. To process an image whose brightness varies in dependent upon the parts of the image, the shadowy part shown in FIG. 8(b) and the bright part shown in FIG. 8(c) are extracted from the one frame of original image.

[0089]

More specifically, a check is made, during extraction processing, for each pixel to see if it is a highlight or a shadow. The binary value "1" is output to the area storage 212b when the pixel is a highlight; the binary value "0" is output to the area storage 212b when the pixel is a shadow. In the description below, those values "1" and "0" are called area information. The area information is used by the gain adjusting circuit 212c to perform different processing for the highlight area and the shadow area.

[0090]

The area storage 212b receives the area information from the area extractor 212a and stores therein the area information on the pixels included in one image. In response to an instruction from the system controller 13A, this information is sent to the gain adjusting circuit 212c.

[0091]

To do brightness correction, the image data is sent from the buffer memory 12b to the gain adjusting circuit 212c after the area information is stored in the area storage 212b. The image data is sent each time an instruction is sent from the system controller 13A to the buffer memory 12b. The number of times the image data is sent equals the number of times white balance correction parameters are to be changed multiplied with the number of times brightness correction parameters are to be changed.

[0092]

When only white balance correction is to be made, the area extractor 212a and the area storage 212b are not active.

[0093]

The gain adjusting circuit 212c is adapted for receiving the image data from the buffer memory 12b, and adjusting the gain of the received image data. More specifically, the gain adjusting circuit 212c processes the image data from the buffer memory 12b according to the instruction from the system controller 13A. This instruction indicates whether to make white balance correction, whether to make brightness correction, the number of times correction parameters are to be changed, or the parameter values (color temperature or exposure amount) to be used.

[0094]

Assume that both white balance correction and brightness correction are to be made, that the white balance correction parameters are to be changed three times, and that the brightness correction parameters are to be changed twice. Then, the system controller 13A issues the instruction described below.

[0095]

First, in order to create area information, the system controller 13A sequentially generates the addresses of the pixels included in one frame of image data and sends them to the buffer memory 12b. At the same time, the system controller 13A tells the area extractor 212a to receive image data from the buffer memory 12b to do the area extraction.

[0096]

After the area extractor 212a performs the area extraction to store area information in the area storage, the system controller 13A sequentially generates the addresses of the pixels included in one frame of image data and sends them to the buffer memory 12b. The system controller 13A repeats this processing six ( $= 3 \times 2$ ) times. At the same time, each time the system controller 13A performs this processing, it sends an instruction to the gain adjusting circuit 212c, indicating whether to make white balance correction and/or brightness correction as well as parameter information (color temperature and exposure amount) to be used during these corrections.

[0097]

The gain adjusting circuit 212c also converts RGB data to luminance data Y and color difference data B-Y and R-Y. The gain adjusting circuit 212c outputs the luminance data Y and the color difference data B-Y and R-Y to the data compressor 11f shown in FIG. 6.

[0098]

The gain adjusting circuit 212c is also adapted to receive from the system controller 13A an instruction indicating whether to perform the black level offsetting, and perform the black level offsetting accordingly. The instruction

indicating whether to perform the black level offsetting is sent to the system controller 13A whenever the user presses the mode selector button which will be described later.

[0099]

Upon receiving a black level offsetting instruction, the system controller checks the gradation values of the pixels stored or the sampled pixels in the buffer memory 12b to determine whether or not the black level offsetting is to be performed. For example, when the number of black level pixels is smaller than a predetermined number and when the number of white level pixels is larger than a predetermined number, the system controller determines that there is a halation in the image. Then, the system controller tells the gain adjusting circuit 212c to decrease the gradation values of the pixels. Conversely, when the number of black level pixels is larger than a predetermined number, the system controller determines that the whole screen is too dark, for example, because the image was photographed at night. Then the system controller instructs the gain adjusting circuit 212c to increase the gradation values of the pixels.

[0100]

When the system controller receives a black level offsetting instruction, it may generate image data for which the black level offsetting is performed, as well as image data for which no black level offsetting is performed, at the same time.

[0101]

The CCD image sensor 11c, preprocessor 11d, A/D converter 11e, signal processor 212, and data compressor 11f are timed with each other in response to the timing signal output from the system controller 13A. The system controller 13A

contains a system controller for controlling the whole electronic still camera 10A, a timing signal generator for generating the timing signal, and an address controller, not shown in the figure. The system controller also controls the timing signal generator and the address controller to control the whole electronic still camera 10A. The timing signal generator, under the control of the system controller, generates the signal driving the whole electronic still camera 10A and the operational timing adjusting signal and supplies these signals to the components as shown in FIG. 6.

[0102]

To store processed image data into the memory card 22, the system controller 13A outputs required data and addresses to the memory card 22 via the input/output interface 11g and the connector 30 of the camera proper and via the input/output interface 21 of the memory card attachment. The required data includes a file name necessary for image data input/output, a photographing date, a photographing condition (exposure value, etc.), and an image processing condition (gain adjusting condition), and the like.

[0103]

The data input unit 11hA includes components for user operation such as a mode selector button, a shutter release button, and a liquid crystal monitor on which the mode of the electronic still camera 10A is displayed, not shown in the figure. When the user manipulates the mode selector button or the shutter release button, the data input unit 11hA outputs operational result data to the system controller 13A.

[0104]

User instructions entered by the mode selector button include whether to perform gain adjusting and, if gain adjusting

is to be performed, whether to perform white balance correction and/or brightness correction. In addition, the number of times the parameters for each of white balance correction and brightness correction are to be changed may be specified. Whether to perform black level offsetting may also be specified.

[0105]

When the system controller 13A receives, before gain adjusting, an instruction which allows the electronic still camera 10A to automatically decide the number of frames, the system controller 13A decides the number of frames that is set as the default value, for example, five frames for white balance correction and four frames for brightness correction.

[0106]

In this embodiment, five types of parameters are provided for white balance correction, and four types for brightness correction. More specifically, for the white balance correction, five color temperature parameters are provided (corresponding to daytime light, morning and evening light, cloudy-day light, incandescent light, and fluorescent light).

[0107]

There are four types of brightness correction. More specifically, the exposure values for the highlight area are 0.0, -0.5, -1.0, and -1.5EV, and four exposure values for the shadow area are 0.0, +0.5, +1.0, and +1.5EV. The exposure values for the highlight area, 0.0, -0.5, -1.0, and -1.5EV, are combined with the exposure values for the shadow area, +1.5, +1.0, +0.5, and 0.0EV. That is, the exposure value of -1.5EV for the highlight area is combined, for example, with the exposure value of 0.0EV for the shadow area. It is to be understood that the present invention is not limited to those specific combinations.

[0108]

When the user specifies the number of frames, the parameters are selected automatically from the above-described five types and four types. For example, if the user selects three types for white balance correction and two types for brightness correction, then daytime light, cloudy-day light, and incandescent light are selected as the white balance parameters. As the brightness correction parameters, -0.5 and -1.0EV are selected for the highlight area, and +1.0 and +0.5EV for the shadow area.

[0109]

The signal processor 212, adapted for processing digital signals, may be implemented in the form of a digital signal processing IC. Because the primary operational function of the processor 212 is multiplication and addition, a general-purpose DSP (Digital Signal Processor) may also be used.

[0110]

Next, the area extractor 212a and the gain adjusting circuit 212c of the signal processor 212, which has the components described above, will be described more in detail.

[0111]

First, the area extractor 212a is described. It is adapted to find out the highlight areas and the shadow areas included in one frame of image and outputs area information indicating which area each pixel belongs to. There are many area extraction methods. The present invention is not limited to any particular area extraction method. In the description of the alternative embodiment, an application will be described in which the edge detection is combined with the area division. With such an application, the area extractor 212a comprises



a luminance signal generator 300, an edge detector 302, and an area divider 304 interconnected as shown in FIG. 9.

[0112]

The luminance signal generator 300 is adapted to generate the luminance signal Y of each pixel based on the color data (RGB data) received from the buffer memory 12b. The luminance signal and RGB data are related as indicated by Expression 2 shown below. The luminance signal generator 300 generates the luminance signal based on this expression. The areas are extracted based on the obtained luminance signal.

[0113]

[Expression 2]

$$Y = 0.30R + 0.59G + 0.11B$$

Areas are extracted in two stages. First, the edge detector 302 detects an edge. The edge detector 302 checks the luminance signal to detect a point (edge) at which the brightness of the image changes, and finds out a candidate for the boundary between the highlight and shadow areas.

[0014]

More specifically, an edge in a boundary between the highlight and shadow regions is a step-type edge whose brightness changes gradually. One method of detecting a step-type edge is to find out the spatial, primary derivative,  $df(x,y)$ , of the brightness signal,  $f(x,y)$ , of each pixel. If the absolute value of the derivative is larger than a predetermined value, then the edge detector 302 determines that the pixel constitutes a step-type edge. The expression  $(x,y)$  represents the spatial (horizontal and vertical) position of a pixel in the coordinates. For example, when one frame of image data is composed of 488 horizontal lines each including 720 pixels,  $1 \leq x \leq 720$  and  $1 \leq y \leq 488$ .

The derivative  $df(x,y)$  is represented by the expression given below.

[0015]

[Expression 3]

$$df(x,y) = (\partial f / \partial x) + (\partial f / \partial y)$$

The absolute value of the derivative is as shown below.

[0116]

[Expression 4]

$$|df(x,y)| = [(\partial f / \partial x)^2 + (\partial f / \partial y)^2]^{1/2}$$

Next, the area divider 304 determines the highlight area and the shadow area. More specifically, the area divider 304 divides the image according to the boundary candidate obtained by the edge detector 302 and, for each obtained area, finds out the number of pixels included in the area and the average of the brightness values of the pixels included in the area. With the number of pixels plotted on the vertical axis and the average of the brightness values of the pixels included in each area on the horizontal axis, the histogram shown in FIG. 10 is created. This histogram typically has two peaks, for example, when the image is photographed against the sun. The peak of the higher brightness part corresponds to the highlight area, and the peak of the lower brightness area to the shadow area.

[0117]

By means of the trough between the two peaks as the threshold, the area divider 304 divides the whole area of the image into two. Specifically, one area whose brightness is higher than the threshold is defined as the highlight area, while the other area whose brightness is lower than the threshold

is defined as the shadow area. After defining the areas as described above, the area extractor 212a outputs to the area storage 212b the binary value "1" for pixels included in the highlight area, and the binary value "0" for pixels included in the shadow area, in response to the address information supplied from the system controller 13A.

[0118]

The area storage 212b retains this area information until the next image is photographed and new area information is written in. The retained area information is output to the gain adjusting circuit 212c in response to an output instruction and address information from the system controller 13A.

[0119]

The gain adjusting circuit 212c receives this area information from the area storage 212b and image data from the buffer memory 12b. From the area storage 212b and the buffer memory 12b, the image data is sent to the gain adjusting circuit 212c in the raster scanning fashion of general CRT monitor. Specifically, one horizontal line of image data is output followed by the next one line of image data. One unit of image data from the buffer memory 12b includes 24 bits in length (8 bits for each R, G, and B data), and is sent in parallel over eight signal lines, i.e. eight bits at a time.

[0120]

FIG. 11 shows the exemplified configuration of the gain adjusting circuit 212c. The gain adjusting circuit 212c comprises the selector 123, the gain control 124, a black level control 1241, a gradation control (LUTs) 125A, the luminance-chrominance matrix 126, the saturation emphasizing circuit 128, and a parameter setter 129A.

[0121]

Table 2 shows how the gain control 124, gradation control 125A, luminance-chrominance matrix 126, and saturation emphasizing circuit 128 convert image data during white balance correction and brightness correction described above.

[0122]

[Table 2]

	Bracketing effect	
	White balance correction	Brightness correction
Gain	Change Kr and Kb	
LUT		Change
Matrix coefficient	Change coefficient for optimum color reproduction	
Saturation emphasis	Change	

The rows Gain, LUT, Matrix coefficient and Saturation emphasis in Table 2 represent how the parameters change during the processing of the gain control 124, gradation control 125A, luminance-chrominance matrix 126, and saturation emphasizing circuit 128, respectively. In Table 2, Kr and Kb represent the gain of R data and B data, respectively.

[0123]

The settings listed in Table 2 will be described. The reason for making the brightness correction to achieve a bracketing effect was described above. The reason for making the gain, matrix coefficient and saturation emphasis change to adjust a white balance will now be described. For photographic representation, the selection of light and color temperature is important. The color temperature varies with the photographing time and photographing location. The image may be tinged with red or blue by changing the color temperature setting. This, in turn, changes the image impression.

[0124]

Therefore, an image photographed at some color temperature is processed at the color temperature setting appropriately selected so that the optimum image is reproduced. Changing the saturation also emphasizes the color. This is

the reason for changing color temperature or saturation during white balance correction. For this reason, the gain, matrix coefficients, and saturation emphasis are changed as listed in Table 2.

[0125]

One or two of the settings of the gain, matrix coefficients, and saturation emphasis may be selectively combined.

[0126]

White balance correction may be made in one of the several ways. For example, a plurality of cases are assumed with respect to the color temperature of the incident light so that the gain, matrix coefficients, and saturation emphasis settings are prepared in accordance with the respective cases of color temperature. The color temperatures to be assumed should include those for daytime light, morning and evening light, cloudy-day light, fluorescent light, incandescent light, etc.

[0127]

Another method is to change the gain, matrix coefficients, and saturation emphasis to maintain white balance regardless of the color temperature of the incident light. Any of the methods may be used in this invention. In the specific embodiment, the color temperatures are set.

[0128]

From the system controller 13A, the parameter setter 129A in FIG. 11 receives an instruction indicating how white balance correction and brightness correction are to be made, as well as the parameters to be used for these corrections, and then sets up the components of the gain adjusting circuit 212c accordingly.

[0129]

More specifically, for use in the gain control 124, the parameter setter 129A has five combinations of gains  $K_r$  and  $K_b$  (corresponding to gains of an amplifier) associated with five color temperatures. In response to an instruction from the system controller 13A, the parameter setter 129A selects one of the gain combinations and outputs the selected one to the gain control 124. In this specific embodiment, the gain  $K_g$  of G data is fixed. The gain control 124 multiplies color data by the received gain. The parameter setter 129A also does the same processing for the luminance-chrominance matrix 126 and the saturation emphasizing circuit 128. The setter 129A outputs the signal indicating a gradation correction curve to the gradation control 125A. The gradation correction curve will be described later.

[0130]

Next, the configuration and the operation of the gain adjusting circuit 212c will be described. The selector 123 distributes RGB data, sequentially sent from the buffer memory 12b, into R data, G data, and B data.

[0131]

The gain control 124 amplifies the data of each color distributed by the selector 123. More specifically, the gain control 124 receives numeric values ( $K_r$ ,  $K_b$ ) predetermined according to the color temperature from the parameter setter 129A and multiplies color data by the numeric values. The multiplication result will be forwarded to the gradation control 125A.

[0132]

The black level control 1241 receives the addition value

(positive or negative integer) from the system controller 13A via the parameter setter 129A and performs the same addition on each R, G and B color data. This processing is the same for all the pixels.

[0133]

The gradation control 125A converts gradation when it receives a brightness correction instruction. At this time, the gradation control 125A receives color data and area information on each pixel from the buffer memory 12b and the area storage 212b, respectively, and also receives an instruction indicating an exposure value from the parameter setter 129A. The gradation control 125A has two gradation correction curves, one for the highlight area and the other for the shadow area, indicating the correspondence between the values of color data sent to the gradation control 125A and the values of color data to be output. The gradation control 125A converts the color data according to this correction curve. FIG. 12 shows examples of gradation correction curves. FIG. 12(a) plots gradation correction curves for the shadow area. The curves indicated by (1), (2), (3), and (4) correspond to the exposure values of +1.5, +1.0, +0.5, and 0.0EV, respectively. FIG. 12(b) plots gradation correction curves for the highlight area. The curves indicated by (1), (2), (3), and (4) correspond to -1.5, -1.0, -0.5, and 0.0EV, respectively. In FIGS. 12(a) and 12(b), the horizontal axis indicates the value of input color data, and the vertical axis indicates the output value of color data with respect to the input color data.

[0134]

The gradation control 125A selects one of the correction curves according to the criterion described below. A set of exposure values of the highlight and shadow areas, for example (-0.5, +1.0), is sent from the parameter setter 129A to the



gradation control 125A. A gradation correction curve to be used is determined based on this information as well as information stored in the area storage in the form of binary "1" and "0". Specifically, when the area information is binary "1", the curve (3) corresponding to -0.5EV is selected from the correction curves shown in FIG. 12(b). When the area information is binary "0", the curve (2) corresponding to +1.0EV is selected from the correction curves shown in FIG. 12(a). The resultant color data, thus corrected in gradation, will in turn be output to the luminance-chrominance matrix 126.

{0135}

The luminance-chrominance matrix 126 performs matrix operation to convert RGB data to luminance signal Y and color difference signals Cr and Cb for optimum color reproduction at each color temperature. Matrix operation is performed according to the expressions described below.

[0136]

[Expression 5]

$$\begin{aligned} Y1 &= K11 \times R1 + K12 \times G1 + K13 \times B1, \\ Cr1 &= K21 \times R1 + K22 \times G1 + K23 \times B1, \\ Cb1 &= K31 \times R1 + K32 \times G1 + K33 \times B1, \end{aligned}$$

where, R1, G1, and B1 are color data that is input to the luminance-chrominance matrix 126. They represent the red, green and blue components, respectively. K11, K12, K13, K21, K22, K23, K31, K32, and K33 are conversion coefficients. Y1 is the luminance signal that is output by the luminance-chrominance matrix 126. Cr1 and Cb1 are color difference signals output by the luminance-chrominance matrix 126. The luminance-chrominance matrix 126 has five sets of conversion coefficients, each set corresponding to one of the color temperatures. The luminance-chrominance matrix 126

selects the conversion coefficients according to the specification of the color temperature from the parameter setter 129A to perform the calculation of Expression 5.

[0137]

The color difference signals Cr1 and Cb1 are sent to the saturation emphasizing circuit 128. The saturation emphasizing circuit 128 receives five sets of coefficients each corresponding to one of the five color temperatures from parameter setter 129A. The received coefficients are multiplied by the color difference signals Cr1 and Cb1.

[0138]

Image data thus processed by the gain adjusting circuit 212c of the signal processor 12 is transferred to the data compressor 11f shown in FIG. 7. The image data may be compressed, for example, according to the JPEG standard.

[0139]

The compressed image data is sent to the memory card 22 and stored therein. The memory card may be a semiconductor memory (flash memory, and the like), a magnetic disk, or an optical disc.

[0140]

Next, the operation of the electronic still camera 10A with the configuration described above will be described.

[0141]

The user manipulates the data input unit 11hA to specify whether to perform gain-adjusting. When the user wishes to do the gain adjusting, he or she must specify whether to make white balance and/or brightness corrections, whether the specification of the number of parameter changes is automatic,

and if not automatic, the number of times the parameters are to be changed. When the user wants to do the black level offsetting, he or she must specify whether to do the offsetting.

[0142]

Upon receiving the user instruction, the system controller 13A decides the number of times the white balance correction parameters are to be changed and the number of times the brightness correction parameters are to be changed. When both white balance and brightness corrections are to be made, the system controller 13A tells the signal processor 212 to do the processing the number of times equal to the number of times white balance correction parameters are to be changed multiplied with the number of times brightness correction parameters are to be changed.

[0143]

In the description below, the operation will be described assuming that the user has specified that both white balance and brightness corrections are to be made, that the white balance correction parameters are to be changed three times, and that the brightness correction parameters are to be changed twice. In this case, six frames of image data will be finally obtained.

[0144]

When the user depresses the shutter release button after specifying the processing mode setting, the imaging device 11c photographs an image of an object. The obtained image data is processed by the preprocessor 11d and the A/D converter 11e and then sent to the signal processor 212. After color-interpolated by the color interpolation circuit 12a of the signal processor 212, the image data is stored in the buffer memory 12b.

[0145]

Since the instruction to perform the black level offsetting has been issued, the system controller 13A makes access to the buffer memory 12b to determine whether to perform addition or subtraction on the gradation values as described above. Before addition or subtraction, the system controller 13A decides the addition value or subtraction value and outputs the decided value to the parameter setter 129A.

[0146]

The instruction to make brightness correction has been issued, so that the area extraction is performed. Each time an output instruction and an address are received from the system controller 13A, the image data is output from the buffer memory 12b to the area extractor 212a. The area extractor 212a extracts the highlight area and the shadow area from each other to store the obtained area information in the area storage 212b.

[0147]

After the area extraction is finished, the image data is output from the buffer memory 12b to the gain adjusting circuit 212c each time an output instruction and an address are received from the system controller 13A. For the first three frames of image data, the gain adjusting circuit 212c uses  $-0.5\text{EV}$  for the highlight area and  $+1.0\text{EV}$  for the shadow area. For the last three frames of image data, the gain adjusting circuit 212c uses  $-1.0\text{EV}$  for the highlight area and  $+0.5\text{EV}$  for the shadow area.

[0148]

The processing shown in Table 2 is repeated in the gain control 124, gradation control 125A, luminance-chrominance matrix 126, and saturation emphasizing circuit 128 of the gain

adjusting circuit 212c six times while varying the parameters. The black level offsetting is also repeated six times in the black level adjuster 1241.

[0149]

The image data thus processed by the gain adjusting circuit 212c is sent to the data compressor 11f for compression. After that, the image data is sequentially stored in the memory card, one frame at a time.

[0150]

Unlike an auto-bracketing camera according to the prior art, the electronic still camera according to the present invention shoots an object to capture an image thereof only once. Therefore, the problem that the photographing timing differs with photographed images does not arise. As a result, the user may obtain a desired image without concerning a movement of the object, the changes of the photographing conditions, or an unintentional movement of the hands of the operator during photographing.

[0151]

The first and second embodiments of the present invention described above differ from each other only in the configuration of the subsequent components of the signal processor after the buffer memory. Because the differing components may be implemented in software, one and the same piece of hardware may be used to implement both of the first and second embodiments when the signal processor is built with a CPU or a DSP. That means that one of or both of the first and second embodiments may be provided in an electronic still camera simply with the software thereof modified accordingly.

[0152]

[Effects of the Invention]

As described above, the image signal processor and its processing method according to the present invention give the user the effect, equivalent to auto-bracketing according to the prior art, by simply photographing an object only once. In addition, a plurality of images may be produced with their own gradation characteristics, color temperature, saturation, contour enhancement, data compression ratio, and black level changed appropriately. Therefore, the problem that the photographing timing differs with photographed images is not involved. As a result, the user may obtain a desired image without taking account of the movement of an object, changes for the photographing conditions, or an unintentional movement of the user's hands during photographing.

[0153]

The method according to the present invention allow the brightness, gradation characteristics, color temperature, saturation, contour enhancement, data compression ratio, and black level of an original image to be changed, thus making it possible to create various images that meet various purposes from one photographed image.

[Brief Description of the Drawing(s)]

[FIG. 1]

FIG. 1 is a schematic block diagram showing the first embodiment of an electronic still camera to which the image signal processor of the present invention is applied;

[FIG. 2]

FIG. 2 is a schematic block diagram showing an exemplified outline configuration of the signal processor of FIG. 1;

[FIG. 3]

FIG. 3 is a schematic block diagram showing an example

of the gain adjusting circuit of the signal processor of FIG. 2;

[FIG. 4]

FIG. 4 is a schematic block diagram showing an example of the usage-specific image processor of the signal processor of FIG. 2;

[FIG. 5]

This figure plots two types of processing performed by the gradation control of FIG. 4;

[FIG. 6]

FIG. 6 is a schematic block diagram showing the second embodiment of an electronic still camera to which the image signal processor of the present invention is applied;

[FIG. 7]

FIG. 7 is a schematic block diagram showing an exemplified outline configuration of the signal processor of FIG. 6;

[FIG. 8]

This figure shows examples of the areas extracted by the area extractor of FIG. 7;

[FIG. 9]

FIG. 9 is a schematic block diagram showing an exemplified outline configuration of the area extractor of FIG. 7;

[FIG. 10]

FIG. 10 is a histogram useful for understanding how the area extractor of FIG. 7 divides an area;

[FIG. 11]

FIG. 11 is a schematic block diagram showing an example of the gain adjusting circuit of the signal processor of FIG. 6; and

[FIG. 12]

This figure plots conversion curves used by the gradation correction of FIG. 11 to make brightness correction.

[List of Reference Numerals]

- 10, 10A electronic still camera
- 11a optical system
- 11b color filter array
- 11c CCD image sensor
- 11e A/D converter
- 12, 212 signal processor
- 12b buffer memory
- 12c, 212c gain adjusting circuit
- 12d usage-specific processor
- 124 gain control
- 125, 125A gradation control
- 126 luminance-chrominance matrix
- 127 edge enhancing circuit
- 128 saturation emphasizing circuit
- 212a area extractor





Fig. 1

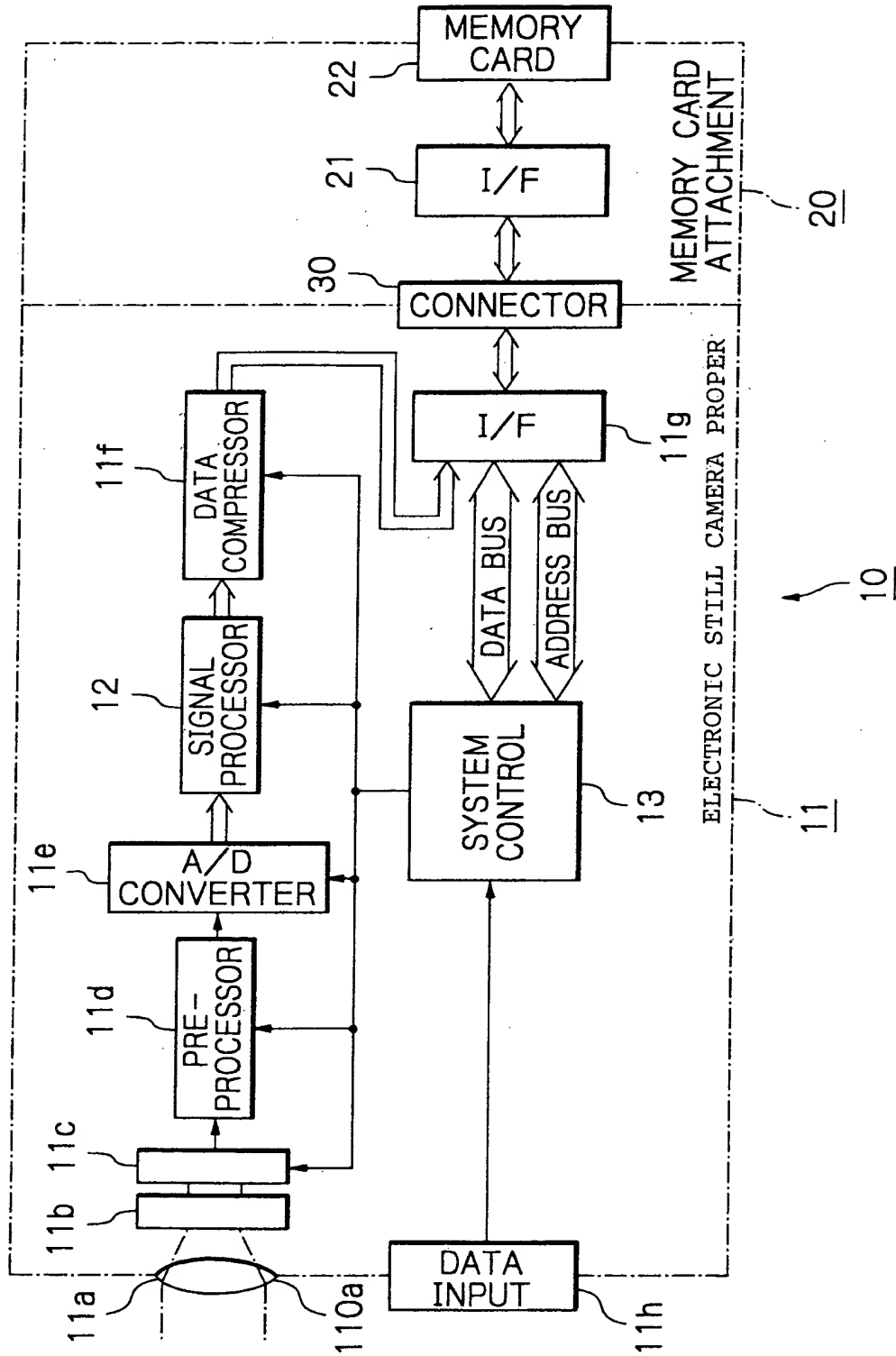
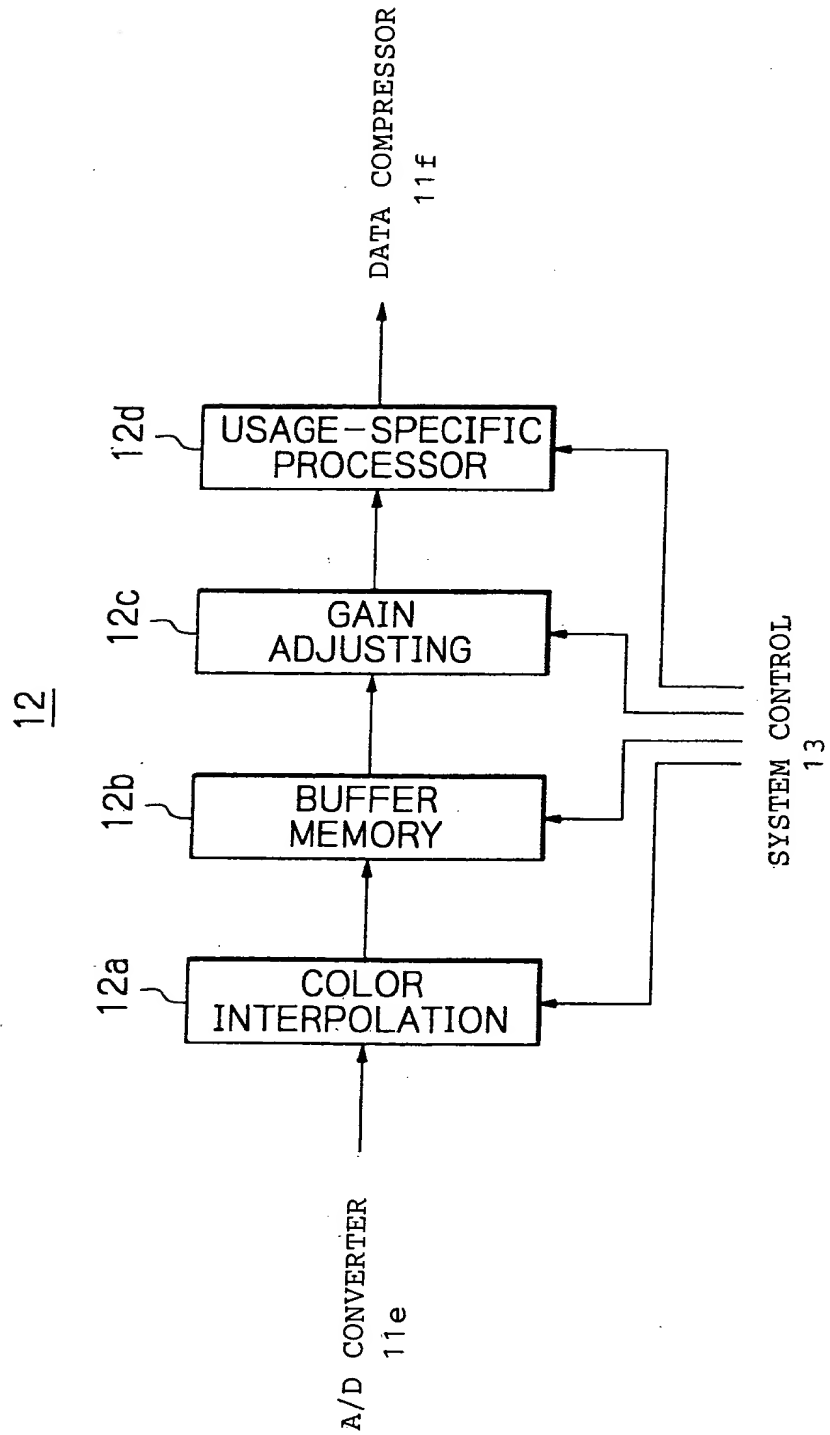
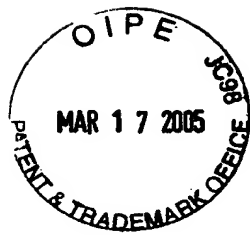




Fig. 2





*Fig. 3*

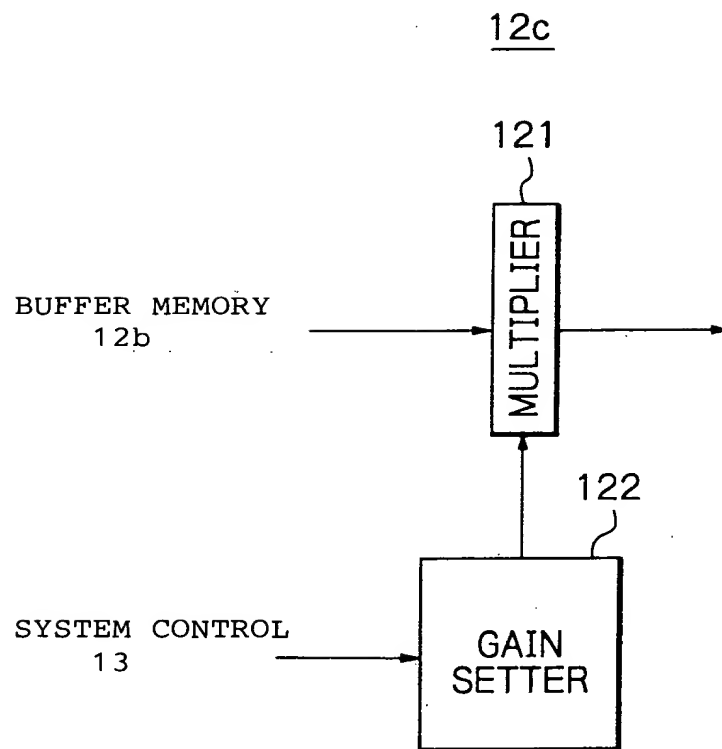
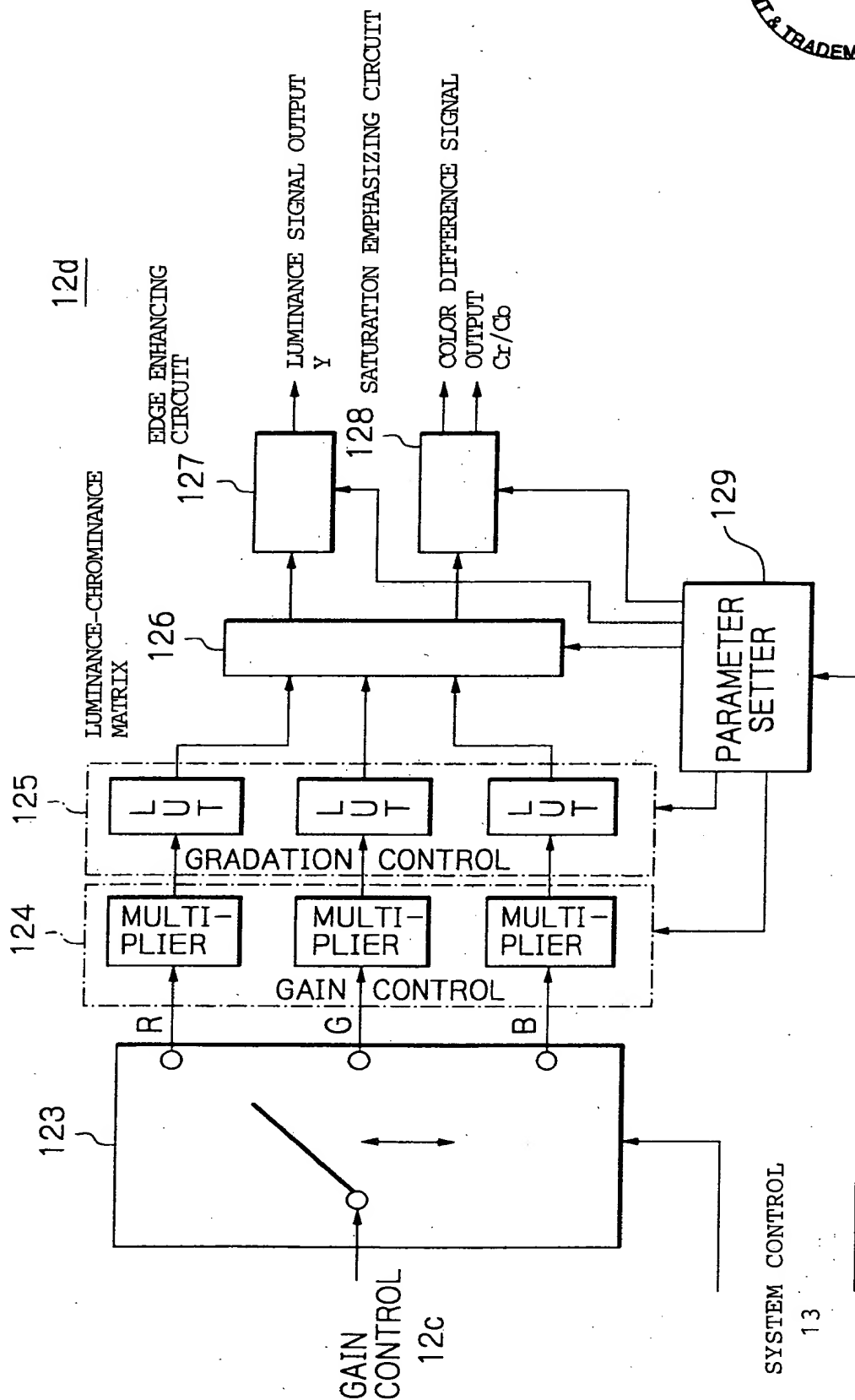
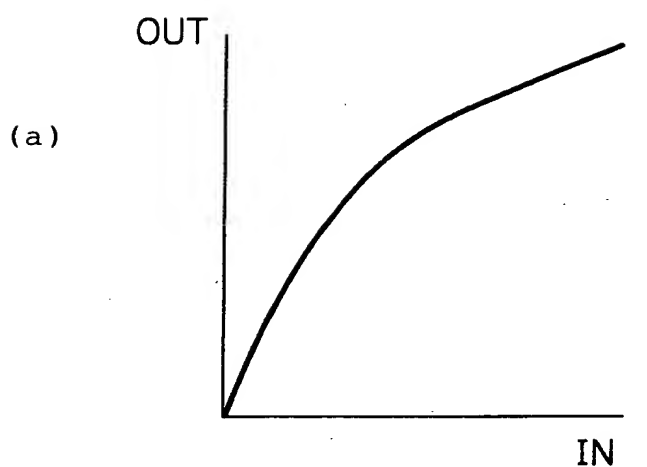


Fig. 4

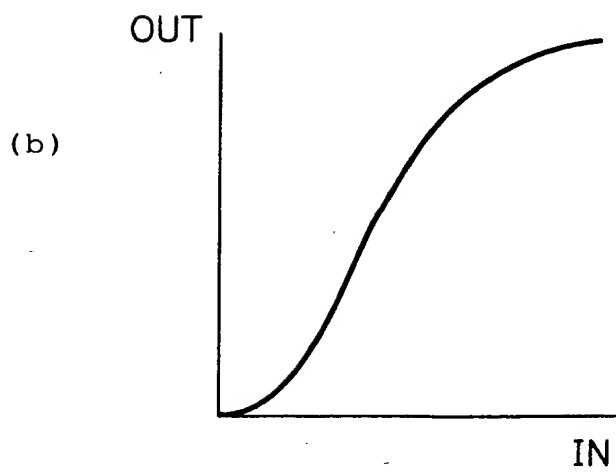




*Fig. 5*



A: CONTRAST DECREASING



B: CONTRAST INCREASING

Fig. 6

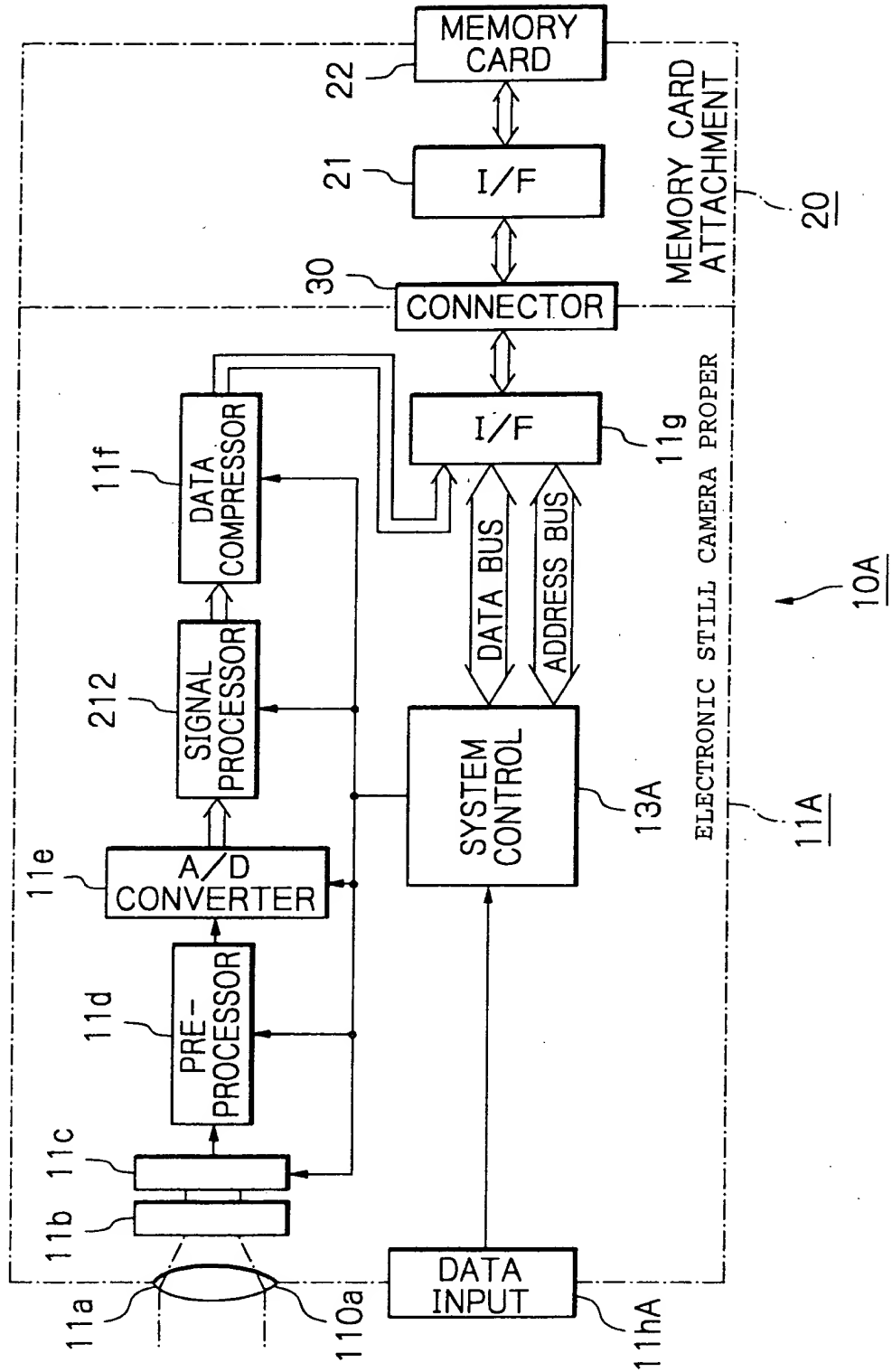
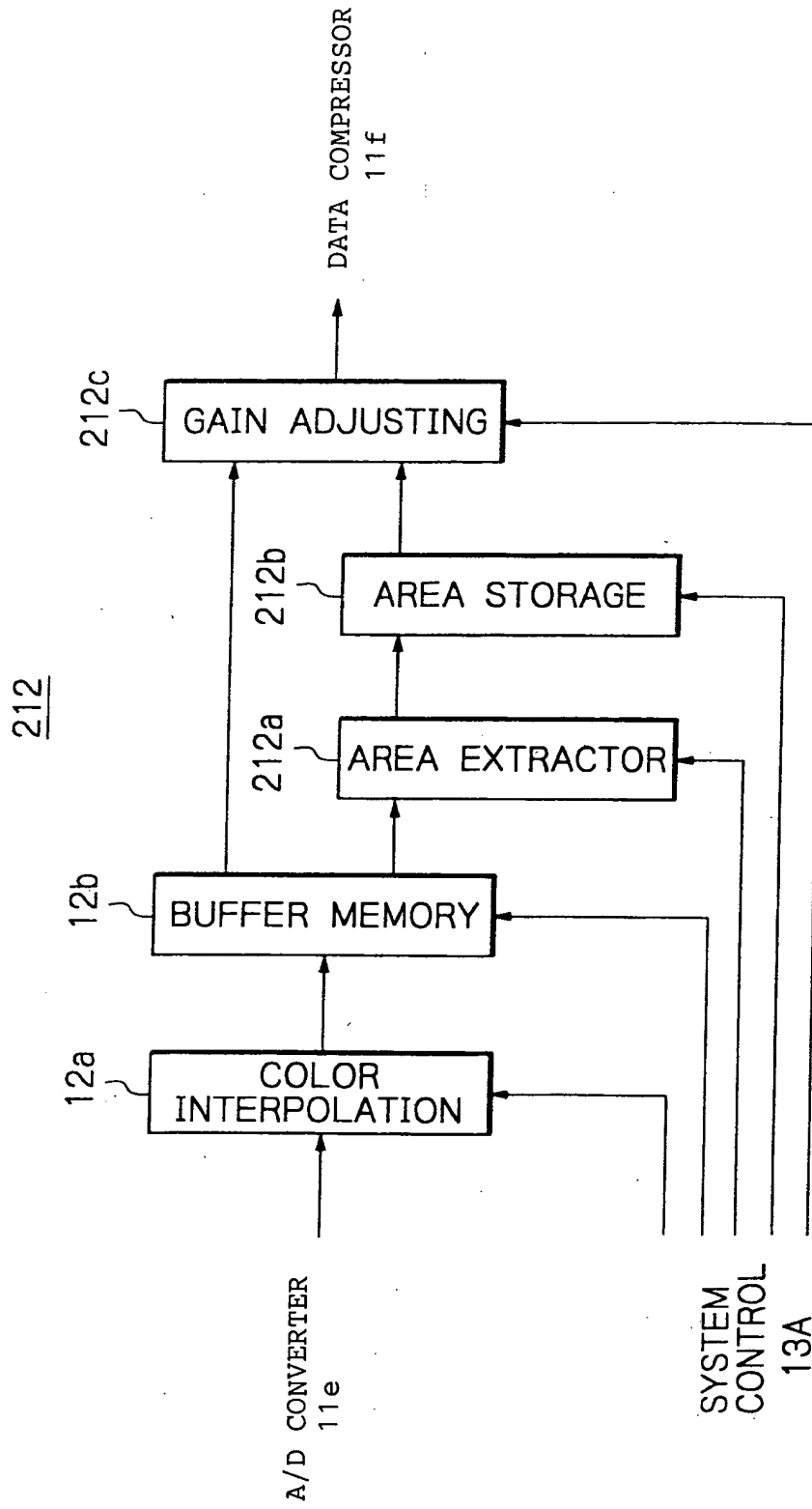




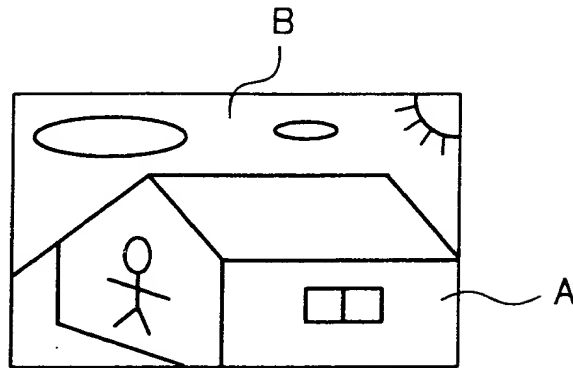
Fig. 7



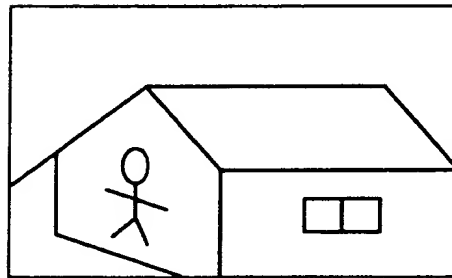


*Fig. 8*

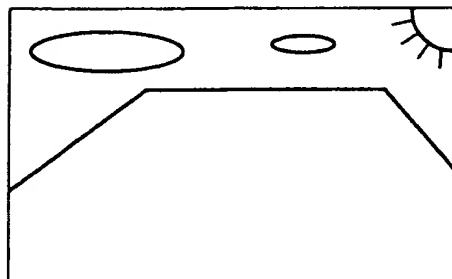
(a)



(b)



(c)







*Fig. 9*

212a

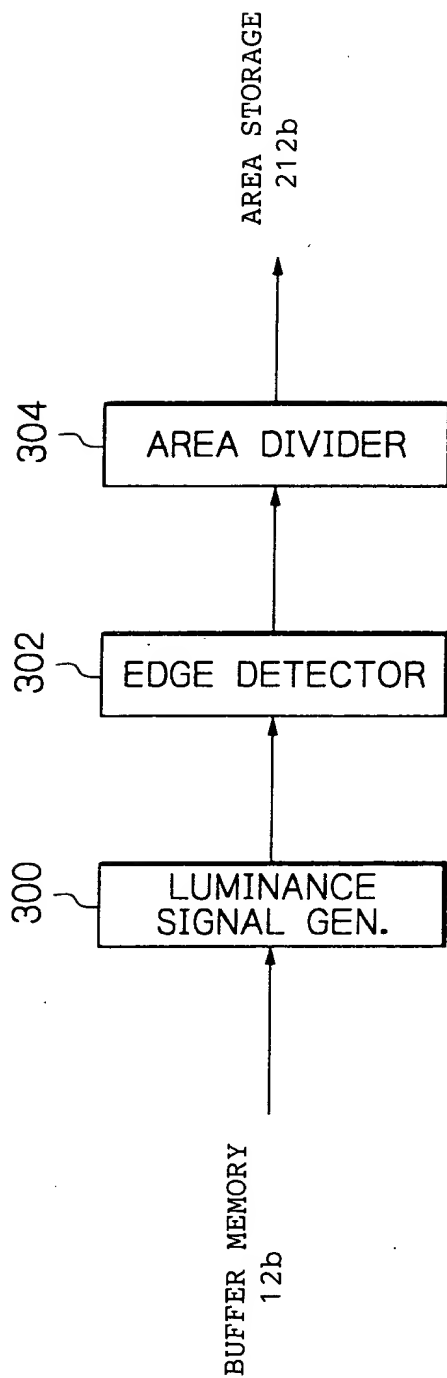




Fig. 10

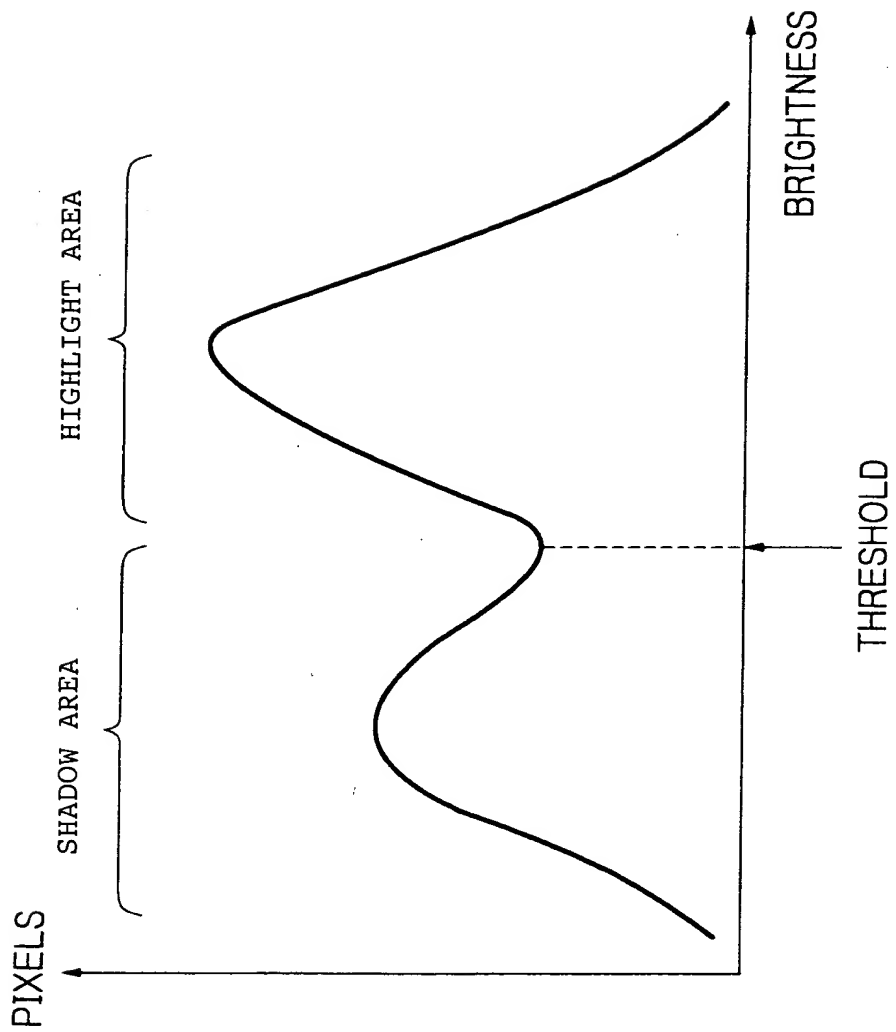
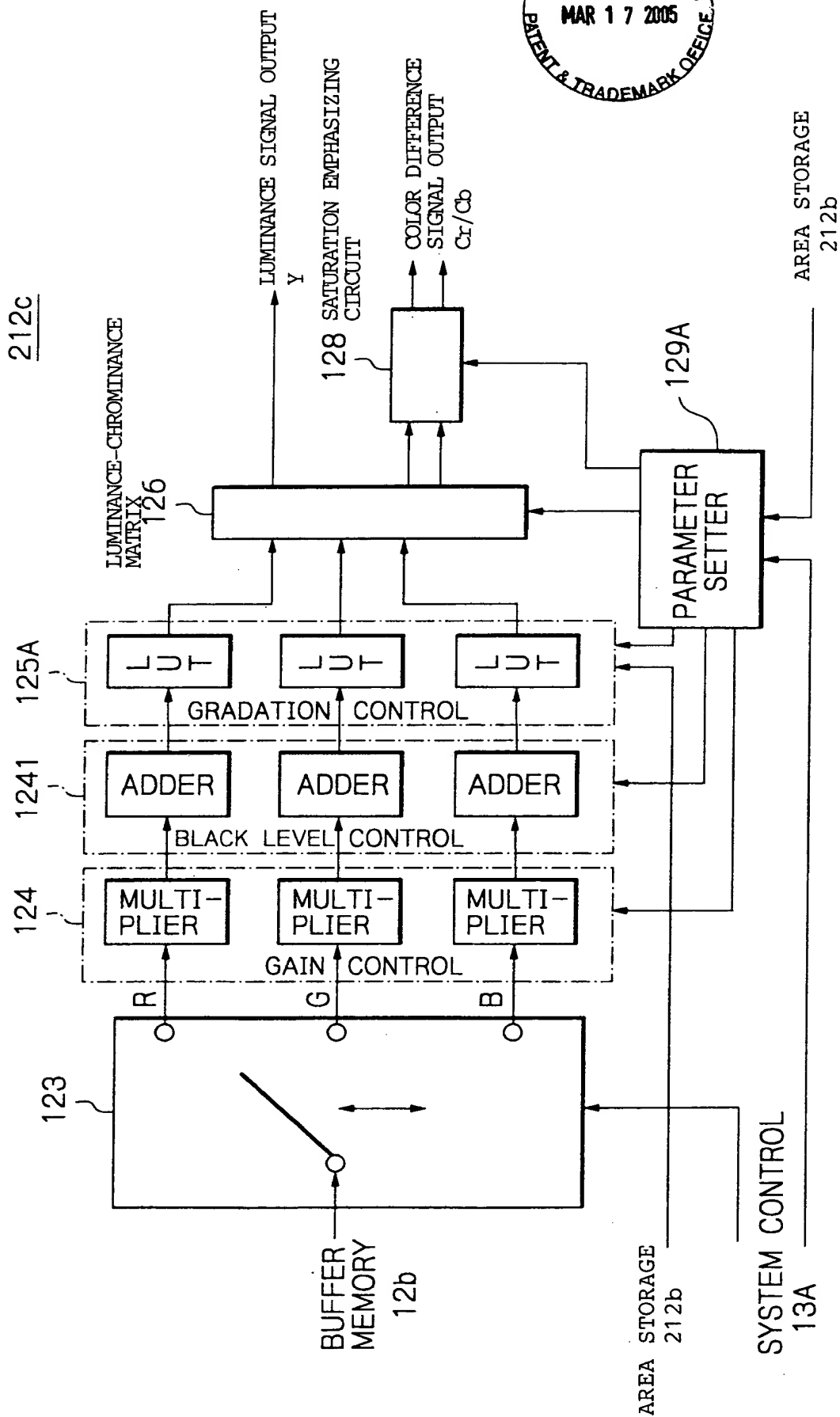
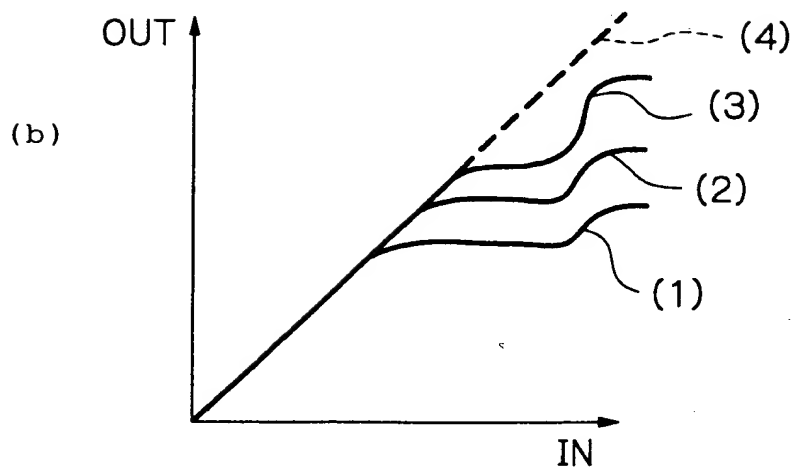
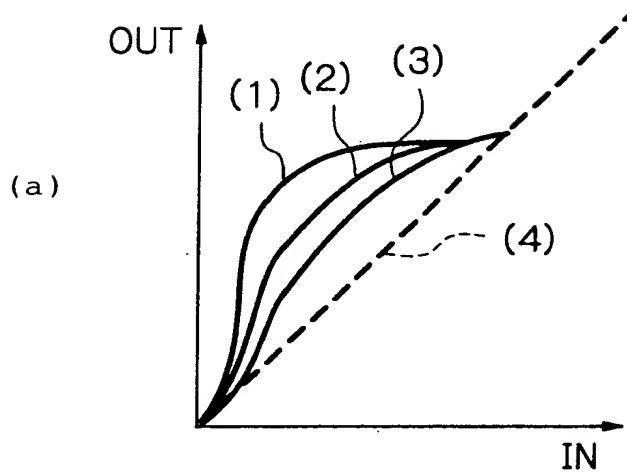


Fig. 11





*Fig. 12*



[Document Name]        ABSTRACT OF THE DISCLOSURE

[Abstract]

[Problem] To provide an image signal processor which can obtain an effect similar to conventional auto-bracketing by simply photographing an object only once.

[Solving Means] A signal processor 12 of an electric still camera stores image data obtained by photographing into a buffer memory 12b. A gain adjusting circuit 12c performs multiplication on the stored image data with the exposure amount charged by 0.5EV at a time. Next, a usage-specific processor 12d processes the image data in two ways to change the gradation, contour and so on, of the image data so that the images data may be output appropriately to a CRT or a printer.

[Figure Selected]    FIG. 2



APPLICANT HISTORY DATA

ID No. [000005201]

1. Date of Rectification August 14, 1990

[Reason for Rectification] Newly Recorded

Address No. 210 Nakanuma, Minami-Ashigara-shi,  
Kanagawa, Japan

Name Fuji Photo Film Co., Ltd.